Con-X Science Panel

Solar System, Planet Formation & Evolution

Feb 2008 report to Con-X FST

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Con-X planetary panel has been rescoped for two reasons:

1. **Dramatic changes in recent research directions**

Topic	<1995	96-00	01-05	06-08
Comets	3	13	18	19
Terrrestrial planets	0	0	12	11
Jovian planets	6	4	14	3
Heliosphere	0	2	13	6
Exoplan & habitability	1	4	11	14
Protoplanetary disks	2	8	28	36
Total / year	1	5	18	45

2. NASA strategic goals strongly reoriented towards planetary issues

Half or more of the Science Plan for NASA's Science Mission Directorate 2007-2016 is devoted to Solar System, heliospherics, exoplanets and habitability. Traditional space astronomy, including high energy astrophysics, is deemphasized.

Consequently, the Con-X planetary panel has been renamed (SSPFE) and covers four areas of research:

- X-rays from Solar System bodies (terr & Jovian planets, comets)
- X-rays from the heliosphere
- X-ray implications for planet habitability
- X-ray implications for protoplanetary disks & planet formation

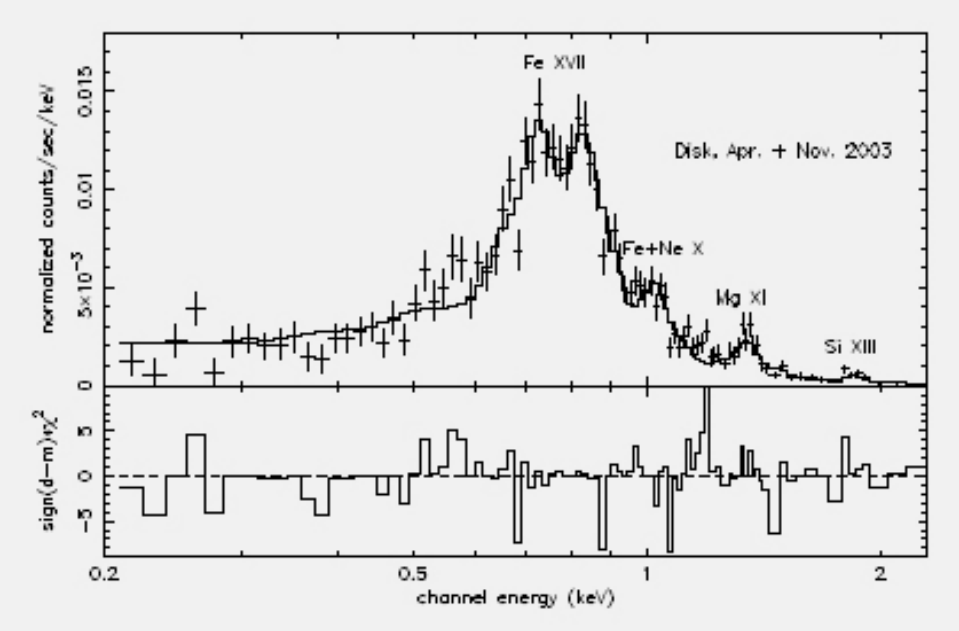
Solar System bodies

Strategic Goal 3.2, Subgoal 1: Progress in understanding the fundamental physical processes of the space environment from the Sun to Earth, to other planets, and beyond to the interstellar medium.
Heliophysics Focus Area: Understand the coupling between planetary ionospheres and their upper atmospheres mediated by strong ion-neutral interactions.

Num	Science Goal	Observation goal	Target/Exposure
SS 1*	Establish physics of solar X-ray and solar wind interactions with terrestrial exospheres	Discriminate fluorescence and charge-exchange X-ray emission; map extended atmosphere of Mars	Venus, Mars @ 0.3 Ms
SS 2*	Determine composition and solar vs. planetary origin of X-ray aurorae and disk of Jovian atmospheres	Test charge-exchange models from O, C and S line spectroscopy	Jupiter @ 0.5 Ms continuously Saturn @ 0.1 Ms

Other projects:

- Test charge exchange models for solar wind/cometary interactions
- Identify active icy bodies in the Asteroid Belt

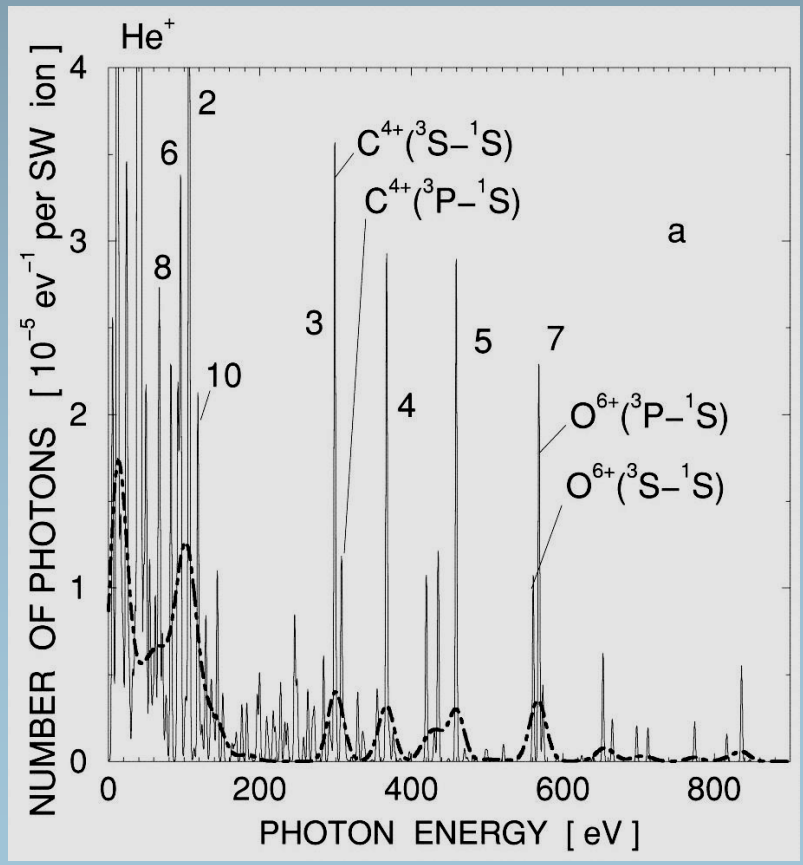


XMM EPIC spectrum of Jupiter's disk

(Branduardi et al. 2006 in Planetary & Space Sci)

Prediction of Jovian/solar wind charge-exchange spectrum

(Kharchenko & Dalgarno 2001 ApJ)

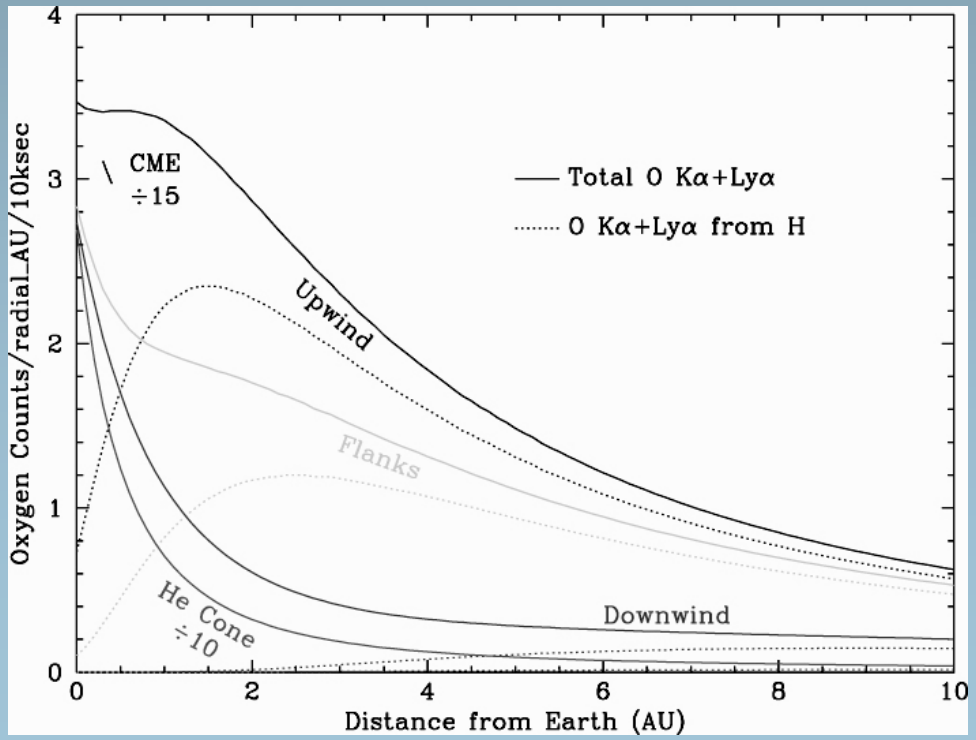


Heliosphere

Strategic Goal 3.2, Subgoal 1: Progress in understanding the fundamental physical processes of the space environment from the Sun to Earth, to other planets, and beyond to the interstellar medium.

Other project:

- Measure contribution of solar wind/ISM charge exchange to soft X-ray background (parasitic to pointed observations)



Location of oxygen charge-exchange lines from solar wind/ISM interaction

Wargelin, priv. comm.

Planet habitability

Strategic Goal 3.3: Advance scientific knowledge of the origin and history of the solar system, the potential for life elsewhere.
Heliophysics Focus Area: Apply our understanding of space plasma physics to the role of stellar activity and magnetic shielding in planetary system evolution and habitability
Heliophysics Science Future Outcomes Beyond 2025: Determine how stellar variability governs the formation and evolution of habitable planets

Num	Science Goal	Observation goal	Target/Exposure
PH 3 *	Quantify flaring of host stars with planets	Measure flaring in stars with planets in habitable zone found with radial velocity and transit methods	Sample of 10 stars @ 80 ks and 40 stars @ 10 ks 1.2Ms total

Other projects:

- Quantify coronal & flare X-ray intensities from solar analogs of different ages & rotations
- Quantify coronal & flare X-ray intensities in stars of different masses & ages

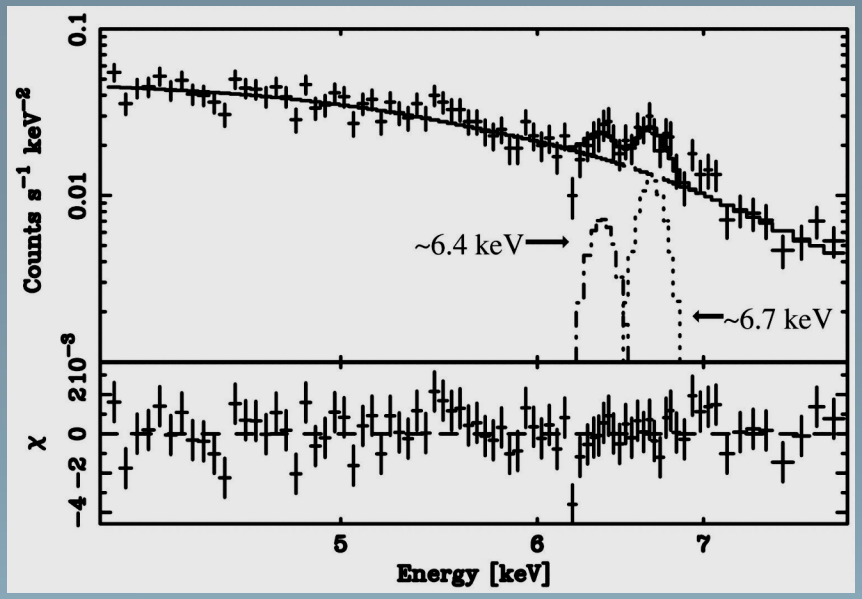
Planet formation

Strategic Goal 3.4: Discover the origin, structure, evolution and destiny of the universe, and search for Earth-like planets. **Subgoal 3:** Progress in understanding how … processes ultimately affect the formation of planetary systems.
Heliophysics Science Future Outcomes Beyond 2025: Determine how stellar variability governs the formation and evolution of habitable planets
Astrophysics Targeted Outcomes Through 2016: Study the birth of stellar and planetary systems. [Various planned NASA missions will] observe protoplanetary disks, each in its own unique way.

Num	Science Goal	Observation goal	Target/Exposure
PF 1*	Establish X-ray irradiation ionization of protoplanetary disks	Measure S and Fe fluorescent line strength in >200 protostars & T Tauri stars	r Oph A, r Oph F, TMC, Serpens, IC 348 @ 100ks
PF 2*	Map structure of protoplanetary disk	Map disks with reverberation of Fe 6.4 keV line strength following flare	YLW 16A & other protostars in r Oph A @ 1 Ms

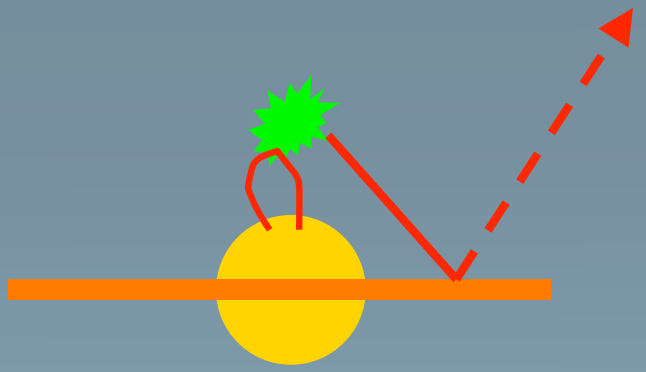
Other project:

- Trace evolution of protoplanetary disks in hostile environments through X-ray mosaics of nascent OB associations

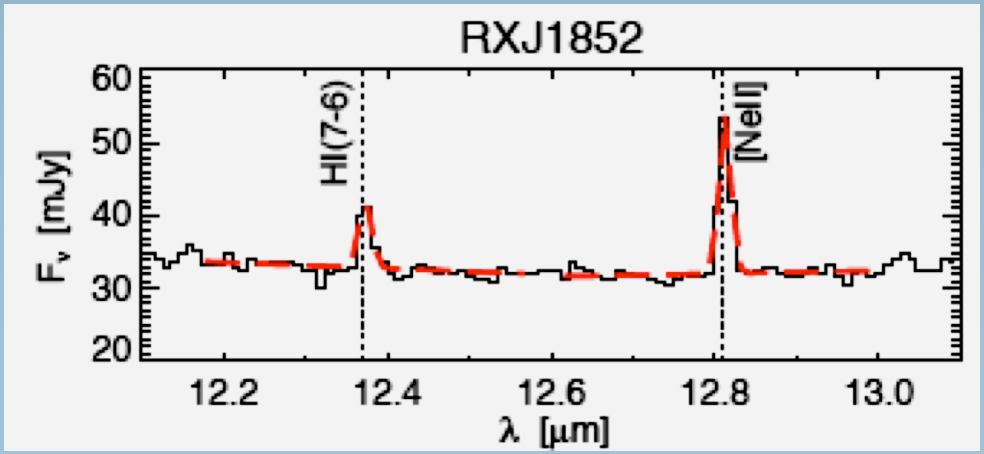


Chandra/YLW 16a Imanishi et al. 2001

Best case of Fe 6.4 keV fluorescent emission line from protostars



Cartoon of X-ray fluorescence from protoplanetary disk



Discovery of X-ray ionization diagnostics [NeII] 12.8 μm & excited H lines in proto-planetary disks

Pascucci et al. 2006

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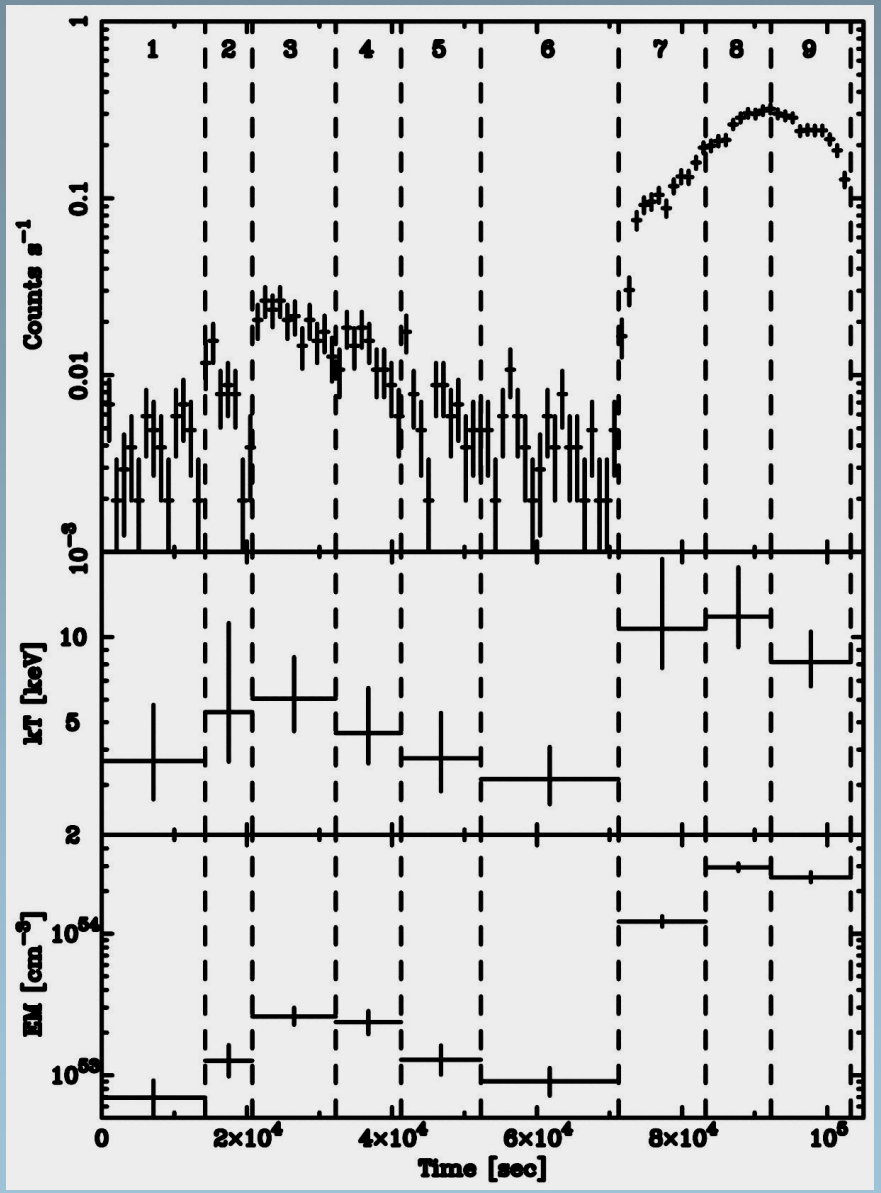

Timescale of proto-stellar flares ~ hours

Physical scale of protoplanetary disks ~ light-hours

Good potential for reverberation mapping of disk using Fe 6.4 keV if sufficient effective area is available

Summary of SSPFE program

1. Elucidate fluorescence and charge-exchange physics in outer atmospheres of Venus, Mars, Jupiter & Saturn

2. Study flaring of specific stars with well-studied habitable planets

3. Survey X-ray fluorescence in large sample of well-studied protoplanetary disks

4. Reverberation mapping of a protoplanetary disk structure following a superflare